TITLE

COMPENSATING ELECTRODE STRUCTURE OF A DISPLAY DEVICE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates in general to an in-plane switching liquid crystal display (IPS-LCD), and in particular to electrode structures of an IPS-LCD.

Description of the Related Art

Liquid crystal displays (LCDs) are classified by the orientation of the LC molecules interposed between the glass substrates. In a conventional twisted nematic LCD (TN-LCD), the LC molecules are twisted between the two substrates. In contrast, in an in-plane switching LCD (IPS-LCD), common electrodes and pixel electrodes are formed on a lower glass substrate (TFT substrate) and an in-plane electric field therebetween is generated for rearranging the LC molecules along the electric field. Accordingly, the IPS-LCD has been used or suggested for improving drawbacks of the conventional TN-LCD, such as a very narrow viewing angle and a low contrast ratio.

In order to achieve better performance of the in-plane electric field, a comb-shaped electrode array is built into the IPS-LCD to solve problems such as an insufficient aperture ratio and crosstalk produced between data lines and common electrodes. FIGs. 1A and 1B are sectional diagrams of a conventional IPS-LCD. FIG. 1C is a top view of the electrode structures of a conventional IPS-LCD. FIG. 1A shows the alignment of the LC molecules in an off state, and FIG. 1B shows the alignment of the LC molecules at an on state. The IPS-LCD has a lower glass substrate 10,

an upper glass substrate 12, and a liquid crystal layer 14 interposed between the two parallel glass substrates 10 and 12. A plurality of strip-shaped common electrodes 16 arranged as a comb-shape structure is patterned on the lower glass substrate 10 serving as a TFT substrate, an insulating layer 18 is deposited on the common electrodes 16 and the lower glass substrate 10, and a plurality of strip-shaped pixel electrodes 20 arranged as a comb-shape structure is patterned on the insulating layer 18.

As shown in FIG. 1A, before an external voltage is applied to the IPS-LCD, the LC molecules 14A are aligned in a direction parallel to the lower glass substrate 10. As shown in FIG. 1B, when an external voltage is applied to the IPS-LCD, an in-plain electric field 22 is generated between the common electrode 16 and the pixel electrode 20, resulting in rotation of the LC molecules 14B toward the in-plane electric field 22.

Depending on the material and the structural design of the common electrode 16 and the pixel electrode 20, the conventional comb-shaped electrode array is classified as three types. FIGs. 2A to 2C are sectional diagrams showing the three types of the common electrode 16 and the pixel electrode 20 in the conventional comb-shaped electrode array. In the first type, as shown in FIG. 2A, the common electrode 16 and the pixel electrode 20 are patterned on the same plane and made of a transparent conductive material, such as ITO or IZO. In the second type, as shown in FIG. 2B, the common electrode 16 made of a non-transparent conductive

material, such as Al and MoW, is patterned on the lower glass substrate 10 and followed by depositing the insulating layer 18. The pixel electrode 20 made of a transparent conductive material, such as ITO or IZO, is then patterned on the insulating layer 18. In the third type, as shown in FIG. 2C, the common electrode 16 and the pixel electrode 20 are patterned on the same plane and made of a non-transparent conductive material, such as Al and MoW. In practice, however, the asymmetrical electrode structure of the IPS-LCD generates image sticking and flicker problems in IPS-LCD, typically referred to the flexoelectric effect.

SUMMARY OF THE INVENTION

To solve the above problems, the present invention provides a display device with compensating electrodes. A liquid crystal layer is interposed between an array substrate and a color filter substrate. A pixel formed by a plurality of compensating electrodes is disposed on an array substrate and the pixel comprises a plurality of first electrodes and second electrodes. A insulating layer is disposed between the first electrode and the second electrode. Each pixel includes a first sub-pixel, a second sub-pixel and a third sub-pixel. The first sub-pixel includes a first and a second domain. The second sub-pixel, which is adjacent to the first sub-pixel, includes a third and a fourth domain. The third sub-pixel , which is adjacent to the first sub-pixel, includes a fifth and a sixth domain.

The first electrodes and the second electrodes are parallel to each other in each domain. The first electrodes are disposed below the second electrodes in the first, fourth and fifth domains. The first electrodes are disposed over the second electrodes in the second, third and sixth domains.

Due to the cause of the position of the reversed first electrodes and the second electrodes in the domain and in adjacent domains, a compensating effect is generated, eliminating the Flexoelectric effect produced by internal DC potential.

A detailed description is given in the following embodiments with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention can be more fully understood by reading the subsequent detailed description and examples with references made to the accompanying drawings, wherein:

FIG. 1A is a cross section of a conventional IPS-LCD, and the liquid crystal molecule arrangement thereof when LCD is powered off;

FIG. 1B is a cross section of a conventional IPS-LCD, and the liquid crystal molecule arrangement thereof when LCD is powered on;

FIG. 1C is a top view of electrode structures of conventional IPS-LCD;

FIGs. 2A to 2C are cross sections of a part of a conventional IPS-LCD;

FIG. 3A is a cross section of the IPS-LCD of the present invention;

FIG. 3B is a top view of the IPS-LCD of the first embodiment of the present invention;

FIG. 4A is a top view of the IPS-LCD of the second embodiment of the present invention.

FIG. 4B is a top view of the IPS-LCD of the third embodiment of the present invention.

FIG. 4C is a top view of the IPS-LCD of the fourth embodiment of the present invention.

FIG. 5A is a cross section along lines I-I', IV-IV' and V-V' in FIG. 3B, and along lines I-I', IV-IV' in FIG. 4A, FIG. 4B and FIG. 4C.

FIG. 5B is a cross section along lines II-II', III-III' and VI-VI' in FIG. 3B, and along lines II-II', III-III' in FIG. 4A, FIG. 4B and FIG. 4C.

DETAILED DESCRIPTION OF THE INVENTION

First Embodiment

As shown in FIG. 3A, in the display device of the present invention, a liquid crystal layer 302 is interposed between an array substrate 300 and a color filter substrate 500.

Referring to FIG. 3B, a pixel formed of a plurality of compensating electrodes is disposed on an array substrate and the pixel comprises a plurality of first electrodes 502 and second electrodes 504. A insulating layer is disposed between the first electrode 502 and the second electrode 504. Each pixel includes a first sub-pixel, a second sub-pixel and a third sub-pixel. The

first sub-pixel, second sub-pixel and third sub-pixel respectively includes a first domain 304 and a second domain 306, a third domain 308 and a fourth domain 310, and a fifth and a sixth domain 312,314. The second sub-pixel is adjacent to the first sub-pixel. The third sub-pixel is adjacent to the second sub-pixel.

The third domain 308 is adjacent to the first domain 304, the fourth domain 310 and the fifth domain 312. The third domain 308, the second domain 306 and the sixth domain 314 are diagonal. The fourth domain 310 is adjacent the second domain 306, third domain 308 and the sixth domain 314. The fourth domain 310, the first domain 304 and the fifth domain 312 are diagonal. The first electrodes 502 and the second electrodes 504 are parallel to each other in each domain. The first electrodes 502 are disposed below the second electrodes 504 in the first, fourth and fifth domains 304,310,312. The first electrodes 502 are disposed over the second electrodes 504 in the second, third and sixth domains 306,308,314.

The first electrodes 502 are formed of non-transparent materials, such as Al or MoW. The second electrodes 504 are formed of transparent materials, such ITO or IZO. Both the first electrodes 502 and the second electrodes 504 can be comb type electrodes.

FIG. 5A is cross section along lines I-I', IV-IV' and V-V' in FIG. 3B. As shown in FIG. 5A, the second electrodes 504 are over the first electrodes 502, and the first electrodes 502 and the second electrodes 504 are intersecting with each other. A insulating layer

518 is formed between the first electrodes 502 and the second electrodes 504.

FIG. 5B is cross section along lines II-II', III-III' and VI-VI' in FIG. 3B. As shown in FIG. 5B, the second electrodes 504 are below the first electrodes 502, and the first electrodes 502 and the second electrodes 504 are intersecting with each other. A insulating layer 518 is formed between the first electrodes 502 and the second electrodes 504.

Consequently, due to the reversed position of the first and the second electrodes 502,504 in the domain and in the adjacent domain, a compensating effect is generated, eliminating the flexoelectric effect produced by internal DC potential. Moreover, the described pixel electrode structure is applicable to large size LCDs for large size LCDs can be allowanced by the muti-domain pixels of the present invention.

Second Embodiment

Referring to FIG. 4A, a plurality of array area are defined on the inner surface of a array substrate. The array substrate is referred to as the TFT (Thin Film Transistor) substrate. The array area is divided by a gate line 402 along the first direction(X direction) and a first data line 404 along the second direction(Y direction), defining a first domain 304, a second domain 306, a third domain 308 and a fourth domain 310, arranged in matrix type. A first thin film transistor 414 and a second thin film transistor 416 are formed on the gate line 402. The first TFT 414 is formed on the left side of first data line 404, and the second TFT 416 is formed

on the right side thereof. The combination of the first domain 304, the second domain 306, the third domain 308 and the fourth domain 310 can be a pixel or a sub-pixel.

The first domain 304 and the second domain 306 are parallel in the same row. The third and the fourth domains 308,310 are in the same column. The first and the third domains 304,308 are in the same row. The second and the fourth domains 306,310 are in the same raw.

The first electrodes 502 in the first domain 304 and the fourth domain 310 include the first and second common lines 418a,418b along the first direction(X direction), and three branches of the first and second common lines 418a,418b along the third direction, wherein the third direction is the direction of the clock-wise rotation from Y direction at an angle between 5° to 15°.

The first electrodes 502 in the second and the third domains 306,308 include a plurality of branches along the fourth direction, wherein fourth direction is the direction of the counter clock-wise rotation from Y direction at an angle between 5° to 15°.

The second electrodes 504 in the first and fourth domains 304,310 each includes a comb stem 504g near the gate line 402, and a plurality of branches along the third direction from the comb stem 504g. The second electrodes 504 in the second and third domains 306,308 include a plurality of branches along the fourth direction.

In the current embodiment, the angle between the third and first direction can differ from the angel

between the fourth and first direction. The two angels, however, are preferably reversed with the same magnitudes. The second electrodes 504 in the second domain 306 are connected to the first TFT 414 through the first contact hole 508. The second electrodes 504 in the third domain 308 are connected to the second TFT 416 through the second contact hole 506. The first electrodes 502 in the third domain 308 are connected to the first common line 418a through the third contact hole 512. The first electrodes 502 in the second domain 306 are connected to the second common line 418b through the fourth contact hole 514.

Third Embodiment

Referring to FIG. 4B, a plurality of array areas 600,700 are defined on the inner surface of an array substrate. The array areas are divided by a gate line 402 along the first direction(X direction) and first and second data lines 404,405 along the second direction(Y direction), defining a first domain 304, a second domain 306, a third domain 308 and a fourth domain 310, arranged in a matrix. A first thin film transistor 414 and a second thin film transistor 416 are formed on the gate line 402, wherein the first TFT 414 is disposed on the left side of the first data line 404, and the second TFT 416 on the left side of the second data line 405. The combination of the first and second domains 304,306 can be a first sub-pixel. The combination of the third and the fourth domains 308,310 can be a second sub-pixel.

Fourth Embodiment

Referring to FIG. 4C, a plurality of array areas 600,700 are defined on the inner surface of an array substrate. The array areas are divided by a gate line 402 along the first direction(X direction) and first and second data lines 404,405 along the second direction(Y direction), defining a first domain 304, a second domain 306, a third domain 308 and a fourth domain 310, arranged in a matrix. A first thin film transistor 414 and a second thin film transistor 416 are formed on the gate line 402, wherein the first TFT 414 is on the right side of the first data line 404, and the second TFT 416 on the right side of the second data line 405. The combination of the first and the second domains 304,306 can be a first sub-pixel. The combination of the third and the fourth domains 308,310 can be a second sub-pixel.

While the invention has been described by way of example and in terms of the preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments. To the contrary, it is intended to cover various modifications and similar arrangements (as would be apparent to those skilled in the art). Therefore, the scope of thee appended claims should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements.